CLAIMS

What is claimed is:

1. An optical circulator that accomplishes bi-directional communication for use in a fiber optic communications network, the optical circulator comprising:

an optically non-reciprocal core through which passes a transmit signal in a transmit direction and a receive signal in a receive direction;

an input port optically communicating with the core and only delivering the transmit signal, with a well maintained state of polarization, to the core in the transmit direction;

an output port optically communicating with the core and only receiving the receive signal from the core in the receive direction; and

a network port optically communicating with the core and receiving the transmit signal in the transmit direction and receiving the receive signal in the receive direction;

wherein, the transmit signal input to the core at the input port is delivered to the network port, and the receive signal input to the core from the network port is output to the output port.

2. The optical circulator of claim 1, wherein an optical fiber is connected to each of the input port, the output port, and the network port.

3. The optical circulator of claim 1, wherein an optical fiber is connected to at least one of the input port, the output port, and the network port.

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4. The optical circulator of claim 1, further comprising an optical fiber optically coupled to the input port, the optical fiber and the input port being polarization maintaining.

5. The optical circulator of claim 1, wherein the optically non-reciprocal core comprises:

a first optical birefringent wedge optically coupled to the input port and the receive port;

a Faraday rotator optically coupled to the first birefringent wedge, the Faraday rotator rotating the polarization of the transmit signal and the receive signal passing therethrough; and

a second optical birefringent wedge optically coupled to the Faraday rotator and to the output port;

wherein the receive signal passes, in the receive direction, through the second birefringent wedge, the Faraday rotator, and the first birefringent wedge without being refracted and the transmit signal passes, in the transmit direction, through the first birefringent wedge, the Faraday rotator, and the second birefringent wedge and is refracted into the network port.

6. The optical circulator of claim 4, wherein the Faraday rotator comprises either a non-latching magnetic material or a latching magnetic material.

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7. The optical circulator of claim 4, wherein the first and second optical birefringent wedges are selected from the group consisting of a Wollaston prism, a Rochon prism, a Glan-Thomson prism, or a Glan-Taylor prism.

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8. An optical circulator that accomplishes bi-directional communication for use in a fiber optic communications network, the optical circulator comprising:

an optically non-reciprocal core through which passes a transmit signal in a transmit direction and a receive signal in a receive direction, the core having a first end and a second end disposed from the first end;

an input port optically communicating with the core and only delivering the transmit signal, with a well maintained state of polarization, to the core in the transmit direction;

a first lens optically coupled to the input port and the core;

an output port optically communicating with the core and only receiving the receive signal from the core in the receive direction;

a second lens optically coupled to the output port and the core;

a network port optically communicating with the core and receiving the transmit signal in the transmit direction and receiving the receive signal in the receive direction; and

a third lens optically coupled to the network port and the core;

wherein, the transmit signal input to the core at the input port is delivered to the network port, and the receive signal input to the core from the network port is output to the output port.

9. The optical circulator of claim 8, wherein the input port and the receive port optically communicate with the core through the first end.

10. The optical circulator of claim 8, wherein the input port optically communicates with the core through the first end and the receive port communicates with the core through the second end.

11. The optical circulator of claim 8, wherein the transmit signal passes through the optically non-reciprocal core following a first optical path, the first optical path being defined by:

a first polarization beam splitter optically coupled to the first lens;

a polarization shifting assembly optically coupled to the first polarization beam splitter; and

a second polarization beam splitter optically coupled to the polarization shifting assembly.

12. The optical circulator of claim 11, wherein the polarization shifting assembly comprises a garnet and a wave plate.

13. The optical circulator of claim 11, wherein the second polarization beam splitter optically communicates with the output port.

14. The optical circulator of claim 11, wherein the second polarization beam splitter optically communicates with the network port.

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15. The optical circulator of claim 11, wherein the receive signal passes through the optically non-reciprocal core following a second optical path for a first polarization state and a third optical path for a second polarization state, the second optical path being defined by the second polarization beam splitter in combination with a garnet and a mirror receiving the receiving signal having the first polarization state.

16. The optical circulator of claim 15, wherein the third optical path is defined by the receive signal having the third polarization state being at least once incident upon:

the second polarization beam splitter;

the polarization shifting assembly optically coupled to the second polarization beam splitter and the second polarization beam splitter;

the first polarization beam splitter optically coupled to the polarization shifting assembly; and

a mirror optically coupled to the first polarization beam splitter.

17. The optical circulator of claim 16, wherein the third optical path is further defined by the receive signal having the third polarization state being at least once incident upon a third polarization beam splitter optically coupled to the first polarization beam splitter and the output port.

18. The optical circulator of claim 11, wherein the receive signal passes through the optically non-reciprocal core following a second optical path for a first polarization state and a third optical path for a second polarization state, the second optical

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path being defined by the second polarization beam splitter in combination with a wave plate and a mirror receiving the receiving signal having the first polarization state.

19. The optical circulator of claim 8, wherein the optically non-reciprocal core comprises:

a polarization beam splitter optically coupled to the first lens;

a polarization shifting assembly optically coupled to the polarization beam splitter along a first optical path; and

a beam displacer optically coupled to the polarization shifting assembly along the first optical path and optically coupled to the polarization beam splitter along a second optical path.

20. The optical circulator of claim 19, wherein the polarization shifting assembly comprises:

a wave plate optically coupled to the polarization beam splitter along the first optical path; and

a garnet optically coupled to the wave plate along the first optical path.

21. The optical circulator of claim 19, wherein the polarization shifting assembly optically communicates with a portion of the polarization beam splitter and the beam splitter.

22. The optical circulator of claim 19, wherein the transmit signal propagates through the core along the first optical path.

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23. The optical circulator of claim 19, wherein at least a portion of the receive signal propagates along the second optical path.

24. The optical circulator of claim 23, wherein at least a portion of the receive signal propagates along a third optical path defined by:

the beam displacer receiving the receive signal;

the polarization shifting assembly optically coupled to the beam displacer; and

the polarization beam splitter optically coupled to polarization shifting assembly.

25. The optical circulator of claim 8, wherein the optically non-reciprocal core comprises:

a first wave plate optically coupled to the first and second lenses;

a first beam displacer optically coupled to the half wave plate;

a polarization shifting assembly optically coupled to the first beam displacer; and

a second beam displacer optically coupled to the polarization shifting assembly and the third lens.

26. The optical circulator of claim 25, wherein the polarization shifting assembly comprises:

a wave plate optically coupled to the first beam displacer; and

a garnet optically coupled to the wave plate.

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27. The optical circulator of claim 25, wherein the transmit signal propagates through the core along a first optical path.

28. The optical circulator of claim 25, wherein a first light beam transmitted from the input port travels with a well maintained state of polarization along a first optical path, passing through the first lens, the core and the third lens into the network port; and

wherein a second light beam transmitted from the network port travels along a second optical path, through the third lens and into the second beam displacer, where the second light beam is split into a first orthogonal component and a second orthogonal component, the first orthogonal component being transmitted along the second optical path through the second beam displacer without refraction, through the polarization shifting assembly and into the first beam displacer, where the first orthogonal component is refracted such that it passes through the first wave plate, through the second lens and into the output port, the second orthogonal component being refracted by the second beam displacer along a third optical path, through the polarization shifting assembly, and into the first beam displacer, where the second orthogonal component is transmitted without refraction through the first wave plate, through the second lens and into the output port.

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